

# **The Measurement of Task Complexity and Cognitive Ability: Relational Complexity in Adult Reasoning**

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A thesis submitted in fulfilment of the requirements for the degree of  
Doctor of Philosophy

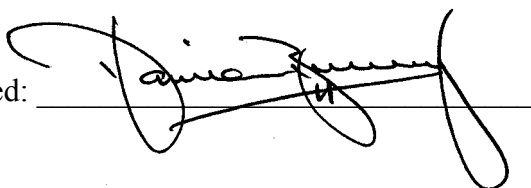
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The work contained in this thesis has not been previously submitted for a degree at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Damian Patrick Birney

Signed: \_\_\_\_\_

A handwritten signature in black ink, appearing to read 'Damian Birney', written over a horizontal line.

Date: 7 March, 2002

## ACKNOWLEDGEMENTS

There are a number of people that need special acknowledgement. First I would like to thank my supervisor Graeme Halford for the guidance and generous support that he has provided over the years. Graeme, I would particularly like to thank you for allowing me the freedom to pursue my research and develop my ideas in such a strong intellectual environment. Thank you also to Gerry Fogarty for getting me started and having faith in me during the early years. You have been instrumental in teaching me an appreciation for psychological measurement and encouraging me to explore good science. I would especially like to thank Julie McCredden who has listened patiently to my ramblings during the last 12 months. Julie, I would of course like to thank you for helping me to enjoy the subtleties of cognition, but more importantly, I would like to thank you for being such a good friend. I would also like to acknowledge the support from all the people in “the lab” and especially Glenda Andrews and Geoff Goodwin. Thank you also to Glen Smith and Julie Duck for reading my early work and to Philippe Lacherez for the many hours of discussions over coffee.

Most importantly I would like to thank my family to whom I dedicate this thesis. Debbie, thank you so much for allowing me to fulfil my dreams. This simply would not have been possible without your love and support. Thank you Corrine for providing me with an endless stream of drawings. Thank you Caleb for encouraging me to take frequent breaks for morning tea. Corrine and Caleb, you gave me the inspiration to keep going when I thought I could go no further. Finally, I would like to thank my parents, Denise and David. Thanks Mum for your hope and showing me what is possible. Thanks Dad for believing in me and showing me what is decent. Thanks to my sisters Ange, Rache, and Gen, and to my brother Anthony, for persevering with me.

Damian Patrick Birney

March, 2002

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## ABSTRACT

The theory of relational complexity (RC) developed by Halford and his associates (Halford et al., 1998a) proposes that, in addition to the number of unique entities that can be processed in parallel, it is the structure (complexity) of the relations between these entities that most appropriately captures the essence of processing capacity limitations. Halford et al. propose that the relational complexity metric forms an ordinal scale along which both task complexity and an individual's processing capacity can be ranked. However, the underlying quantitative structure of the RC metric is largely unknown. It is argued that an assessment of the measurement properties of the RC metric is necessary to first demonstrate that the scale is able to rank order task complexity and cognitive capacity in adults. If in addition to ordinal ranking, it can be demonstrated that a continuous monotonic scale underlies the ranking of capacity (the natural extension of the complexity classification), then the potential to improve our understanding of adult cognition is further realised. Using a combination of cognitive psychology and individual differences methodologies, this thesis explores the psychometric properties of RC in three high level reasoning tasks. The Knight-Knave Task and the Sentence Comprehension Task come from the psychological literature. The third task, the Latin Square Task, was developed especially for this project to test the RC theory.

An extensive RC analysis of the Knight-Knave Task is conducted using the *Method for Analysis of Relational Complexity* (MARC). Processing in the Knight-Knave Task has been previously explored using deduction-rules and mental models. We have taken this work as the basis for applying MARC and attempted to model the substantial demands these problems make on limited working memory resources in terms of their relational structure. The RC of the Sentence Comprehension Task has been reported in the literature and we further review and extend the empirically evidence for this task. The primary criterion imposed for developing the Latin Square Task was to minimize confounds that might weaken the identification and interpretation of a RC effect. Factors such as storage load and prior experience were minimized by specifying that the task should be novel, have a small number of general rules that could be mastered quickly by people of differing ages and abilities, and have no rules that are complexity level specific.

The strength of MARC lies in using RC to explicitly link the cognitive demand of a task with the capacity of the individual. The cognitive psychology approach predicts performance decrements with increased task complexity and primarily deals with aggregated data across task condition (*comparison of means*). It is argued however that to minimise the subtle circularity created by validating a task's complexity using the same information that is used to validate the individual's processing capacity, an integration of the *individual differences* approach is necessary. The first major empirical study of the project evaluates the utility of the traditional dual-task approach to analyse the influence of the RC manipulation on the dual-task deficit. The *Easy-to-Hard* paradigm, a modification of the dual-task methodology, is used to explore the influence of individual differences in processing capacity as a function of RC. The second major empirical study explores the *psychometric approach* to cognitive complexity. The basic premise is that if RC is a manipulation of cognitive complexity in the traditional psychometric sense, then it should display similar psychometric properties. That is, increasing RC should result in an increasing monotonic relationship between task performance and Fluid Intelligence (Gf) – the *complexity-Gf* effect. Results from the *comparison of means* approach indicates that as expected, mean accuracy and response times differed reliably as a function of RC. An interaction between RC and Gf on task performance was also observed. The pattern of correlations was generally not consistent across RC tasks and is qualitatively different in important ways to the *complexity-Gf* effect. It is concluded that the Latin Square Task has sufficient measurement properties to allows us to discuss (i) how RC differs from complexity in tasks in which expected patterns of correlations are observed, (ii) what additional information needs to be considered to assist with the *a priori* identification of task characteristics that impose high cognitive demand, and (iii) the implications for understanding reasoning in dynamic and unconstrained environments outside the laboratory. We conclude that relational complexity theory provides a strong foundation from which to explore the influence of individual differences in performance further.